Configuring *Antelope* for standard seismic network processing

March, 2010

Antelope User Group Meeting

Prague, Czech Republic

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BOULDER REAL TIME TECHNOLOGIES, INC.

Configuring Antelope for Automated Seismic Network Processing

- Reasonable expectations for what a particular seismic network can accomplish (regardless of the software used)

- Antelope configuration suggestions to get the most out of your seismic network

- Streamlining your network operations

- New Antelope configuration tutorial

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Reasonable Expectations

- No matter how great the software, the ability to accurately and reliably locate and characterize earthquakes depends on the seismic data

- Seismic data characteristics fall into two general categories; network geometry and data quality

- Let us start by looking at how network geometry affects the ability to accurately and reliably locate and characterize earthquakes

- Note my strong personal opinion that bad results are worse than no results

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Network Geometry

- Two general characteristics; numbers of stations and spatial distribution of stations, especially the network aperture
- In order to produce accurate and reliable results, the Antelope associator requires a certain minimum number of independent stations (independent station meaning not sharing or nearly sharing the same location of another station)

Numbers of independent stations	False event rate
4	50%
5	20%
6	10%
7	5%
8	2%
9	1%
>= 10	< 1%

Why Can't I Achieve Accurate and Reliable Automated Results With 4 Independent Stations?

- You could if 1) you have perfect data quality and 2) there is no noise
- Noise is usually the big problem
  - Stationary stochastic noise will obscure phase arrivals for weak events causing either detections to be missed or the detection onset times to be randomly delayed
  - Local non-stationary cultural noise will cause spurious detections unrelated to local earthquake activity
- A 4 station earthquake location from a single phase arrival is intolerant to ANY detection onset time errors
- A skilled analyst can mitigate this to a certain extent by 1) manually rejecting spurious noise detections, 2) revise automated detection times to account for stationary noise aliasing, 3) manually pick weak secondary phases to further constrain the location
- The Antelope automated system uses the redundancy from independent stations (as many as possible) to mitigate the noise problems

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Network spatial distribution

- Antelope works best with networks that have many stations over large spatial scaled (this may be counterintuitive)

- In order for automated locations to be accurate and reliable, you will need to see events from at least 6-8 stations.

- The region over which you can obtain good locations is commensurate with the aperture of the network

- Network operators should do everything they can to increase their effective network apertures and the numbers of stations used in the automated processing. This may require inclusion of data from external sources.

- Small aperture networks with not many stations present the greatest problems for automated processing

What Performance is Possible from a Small Aperture Network?

- If the data is processed manually with a skilled seismic analyst, a lot can be done, especially if the analyst can accurately read S arrivals.

- However, with a totally automated system, it is often difficult to impossible to produce reliable locations for events well outside of the network aperture
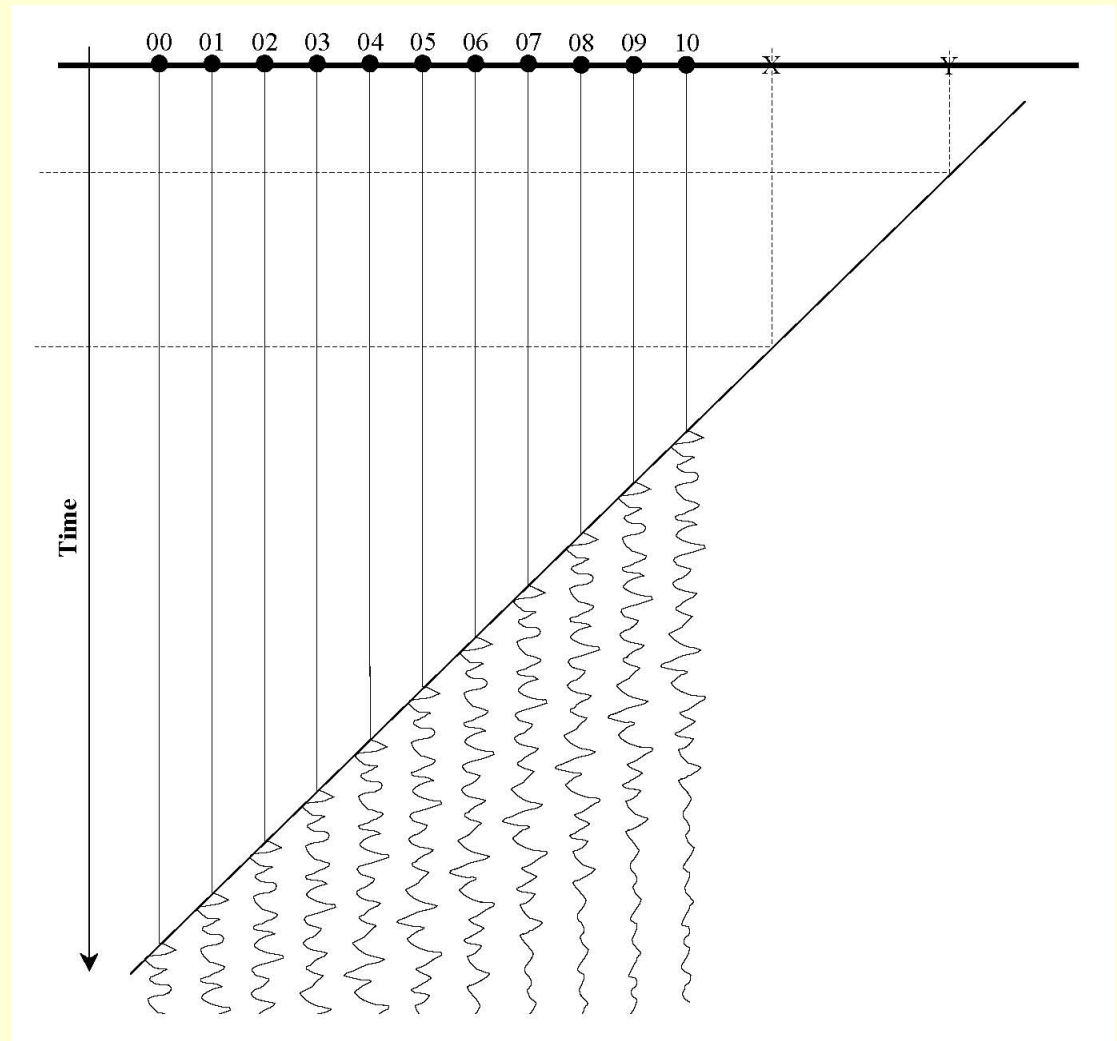
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Why Do Networks Produce Poor Solutions for Events Outside of the Network Aperture?

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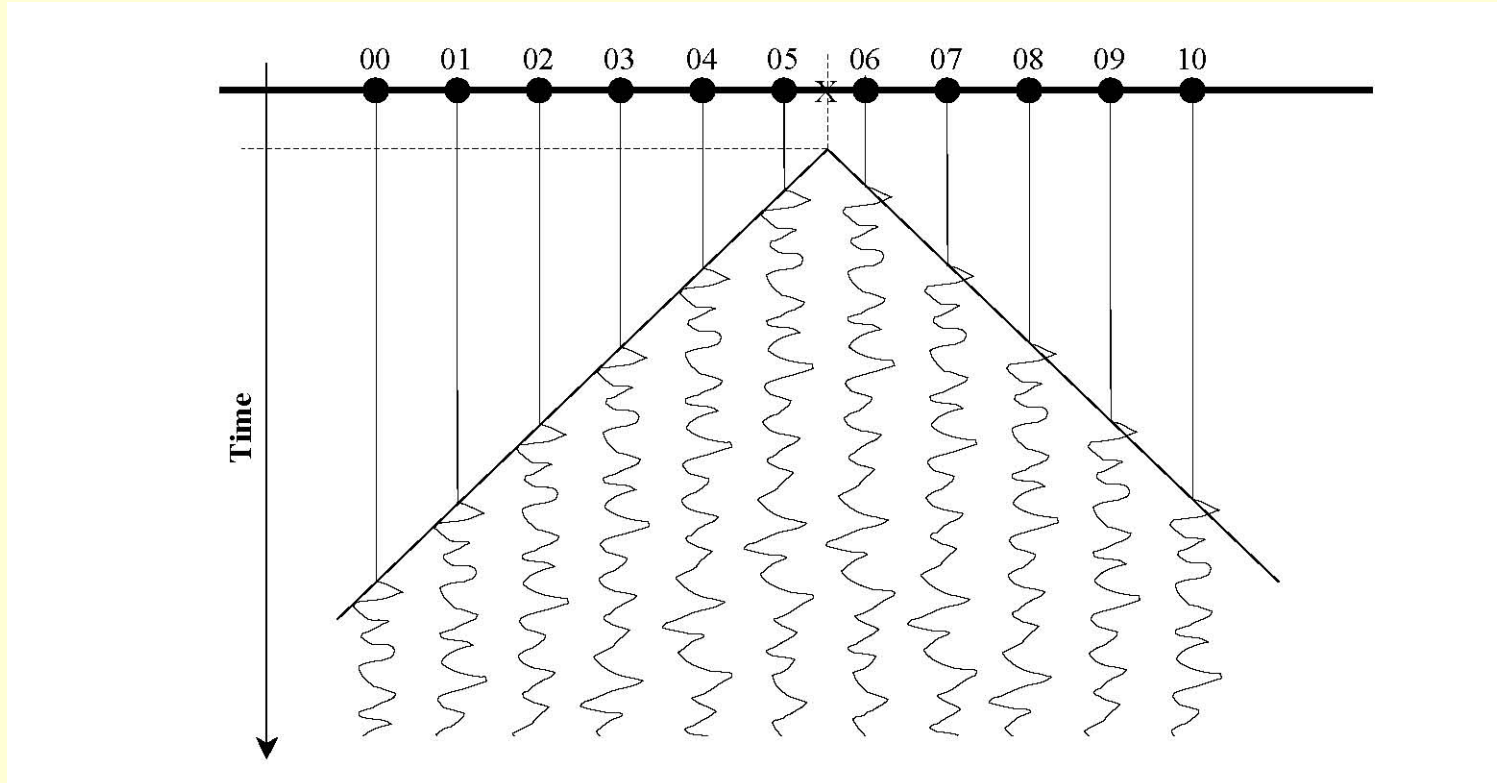
Why Do Networks Produce Poor Solutions for Events Outside of the Network Aperture?

Note that small aperture networks measure differential travel times (the relative arrival times of a phase arrival) over differential distance (the network aperture). In other words, a small aperture network measures horizontal phase slowness. For a single phase, the actual distance to the event must be inferred from the measured horizontal phase slowness

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Why Do Networks Produce Poor Solutions for Events Outside of the Network Aperture? - Real World

Answer:

For events outside of the network aperture, a small aperture network measures horizontal phase slowness, not the actual distance to the event. The distance is determined by the theoretical phase slowness to distance function.

10.00 depth Slownesses for iasp91

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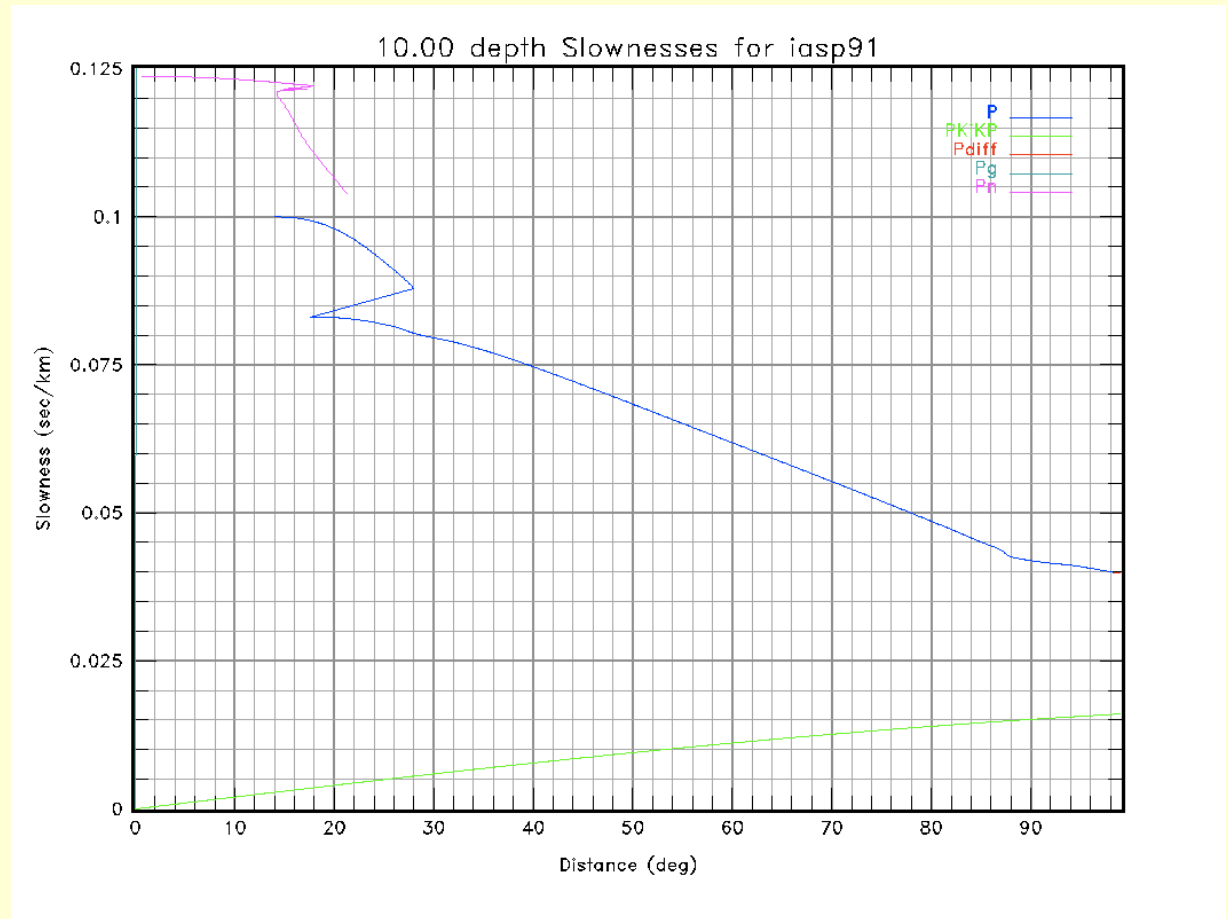
What Performance is Possible from a Small Aperture Network? How can we increase the performance?

- The aperture of a small aperture network can be effectively increased by merging data from other regional to global scale networks. When an event is surrounded by stations it can be located more reliably with only P arrivals and is less sensitive to the velocity model being used to compute theoretical travel times.

- Skilled analysts can read weak S arrivals and use the S-P time to constrain the distance to events outside of the network. Note that this approach produces locations that are highly dependent on the velocity models used. Also the location error ellipses for events located in this manner tend to be large, even with the inclusion of S arrivals.

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What Does the Associator "See"?

Answer:

The associator ONLY sees times, times of detections and times of predicted phase arrivals from a grid of candidate source locations
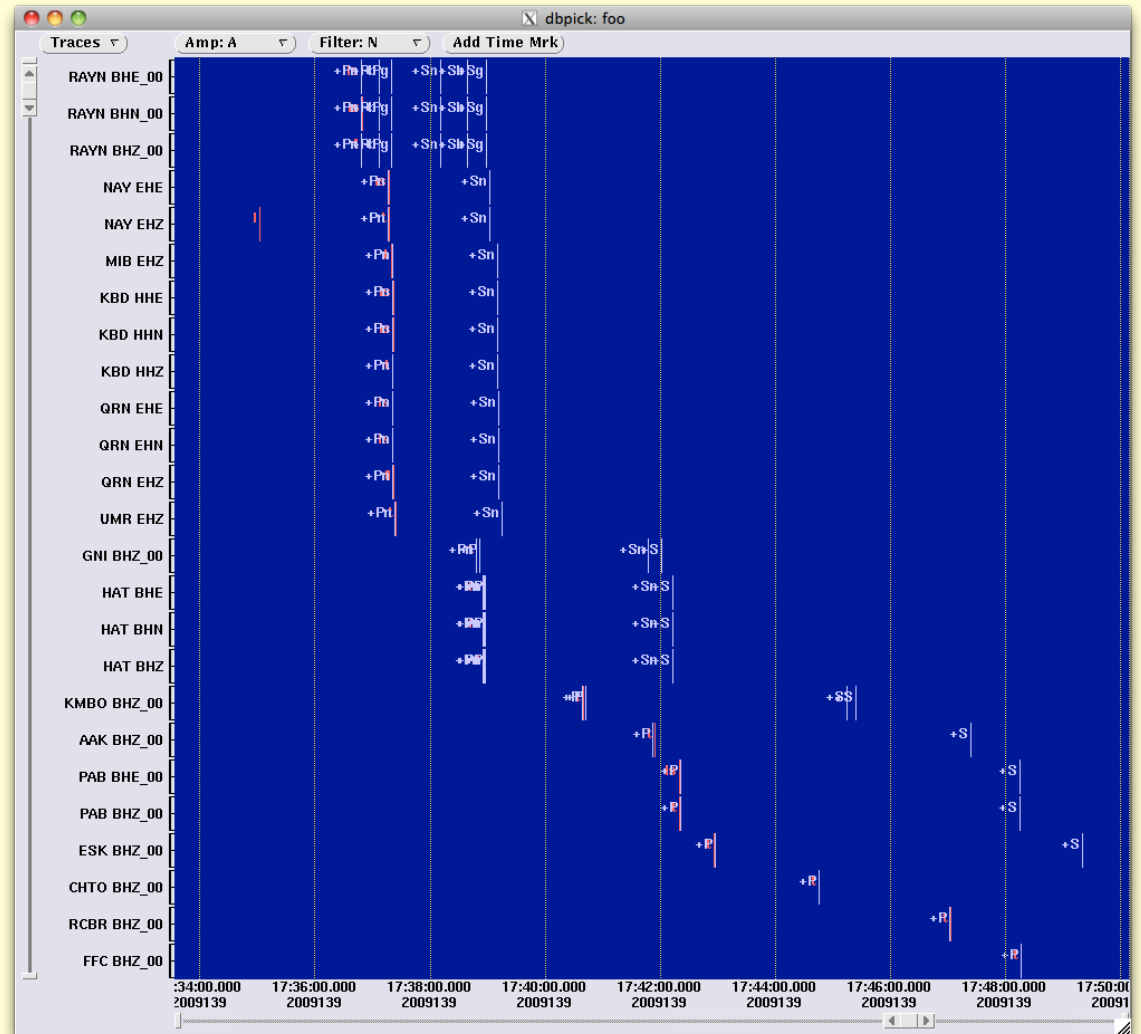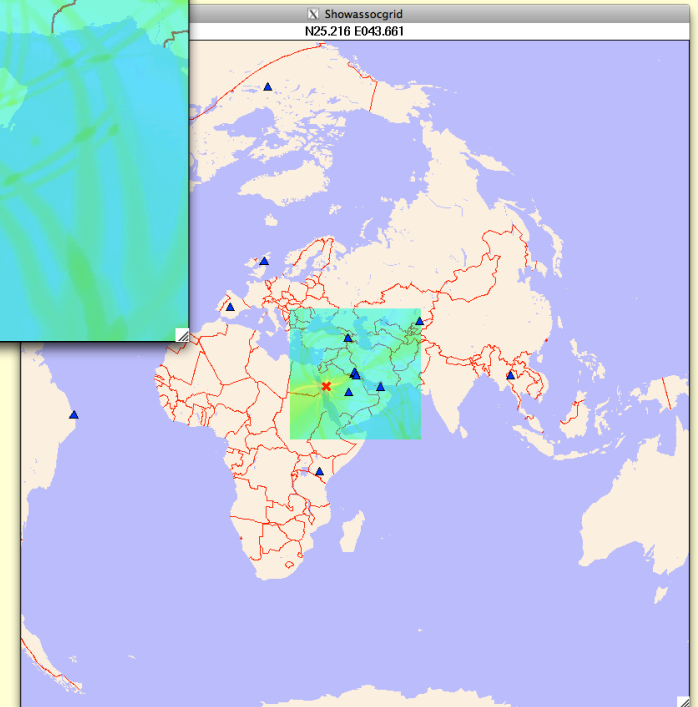
How Does the Associator "Find" a Location?

Answer:

By iterating over a grid of candidate source locations to find the location with the most number of predicted first P arrivals that fit the observed detections.
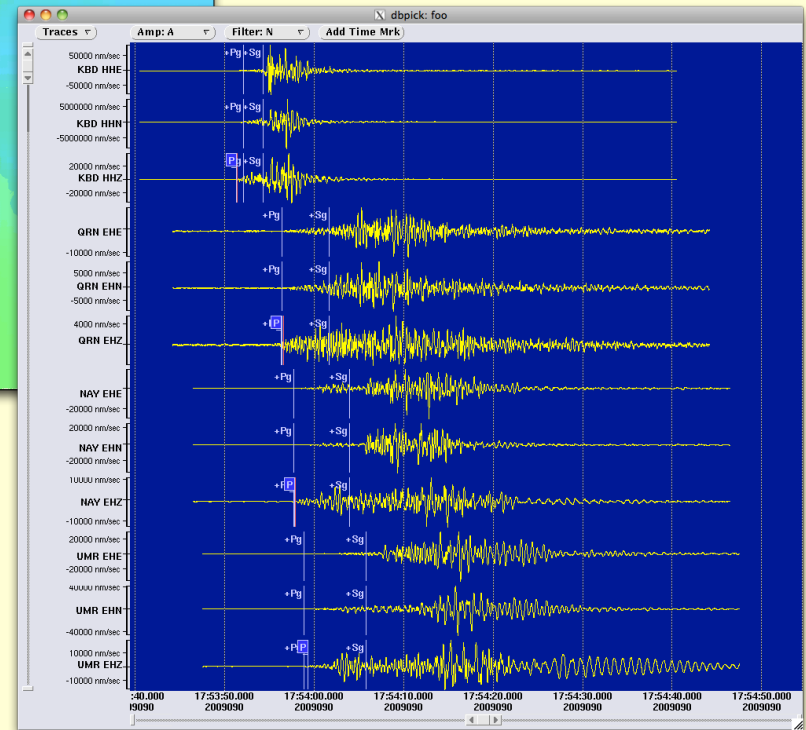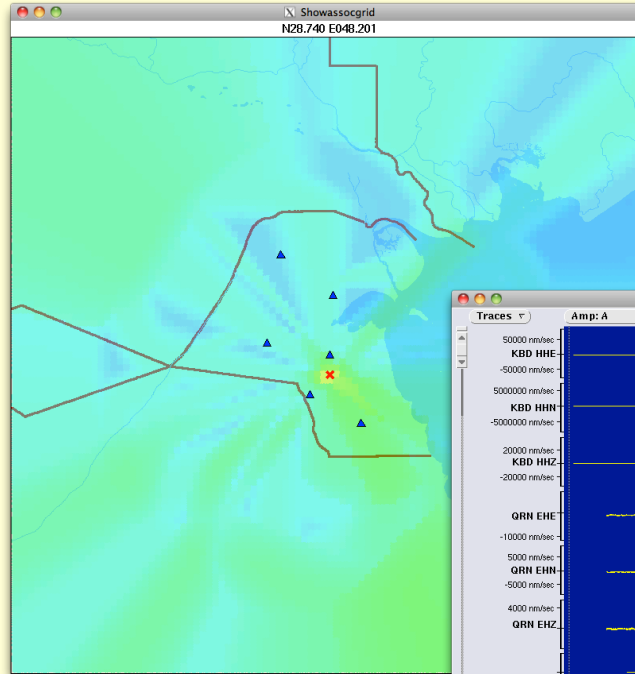

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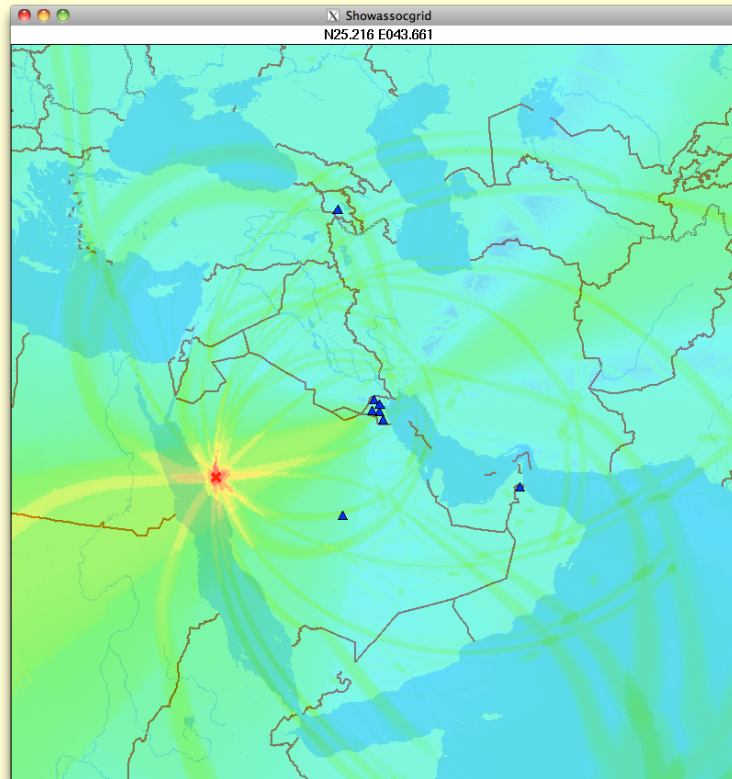
How Well Does the Associator Work for Small Networks? - Local Events
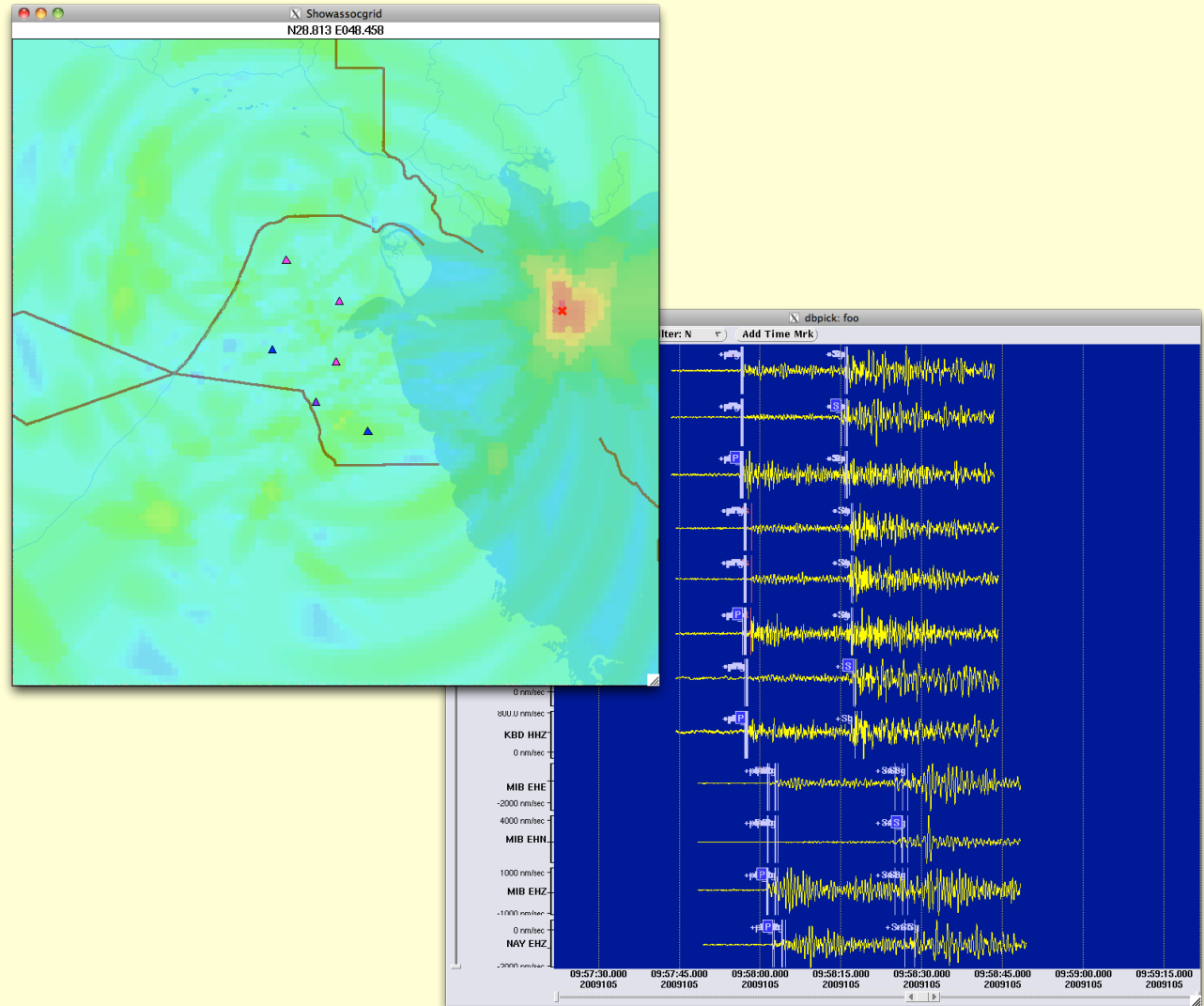
Answer:

Good results for events within network (i.e. event surrounded by stations), with only clear P arrivals. S arrivals help with depth. Need at least 6 stations.

How Well Does the Associator Work for Small Networks? - "Near" Local Events

Answer:

Good results for events within one network aperture, clear P and S arrivals. If only P arrivals, not so good. Need at least 6 stations. Note that the associator always needs a reasonable solution from P arrivals only - the S associations are done in a refinement iteration.

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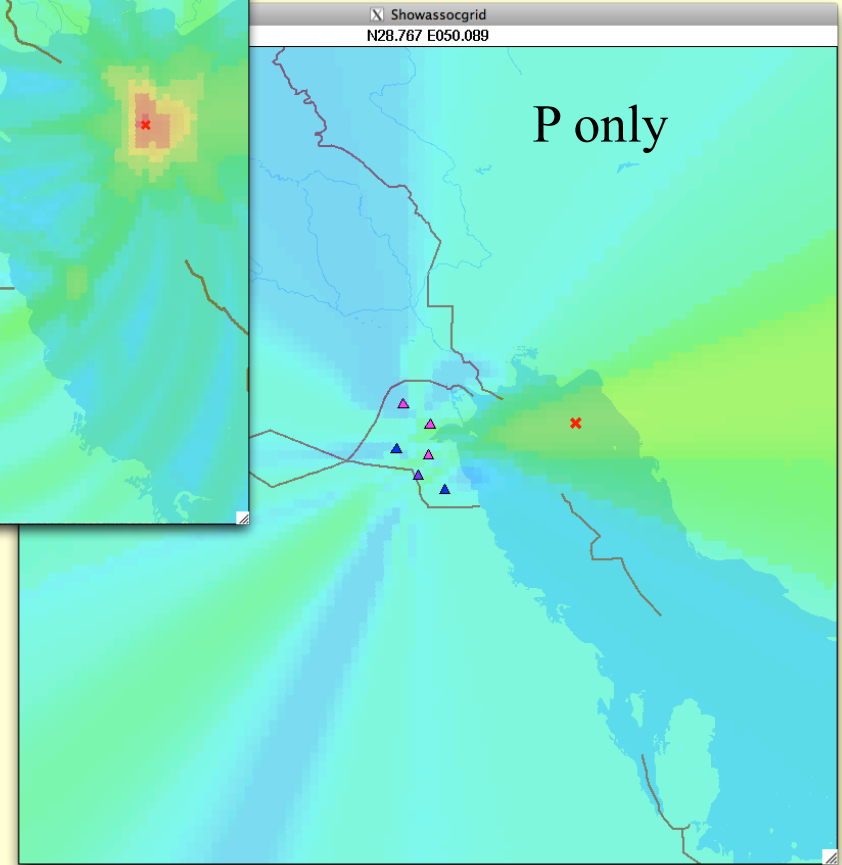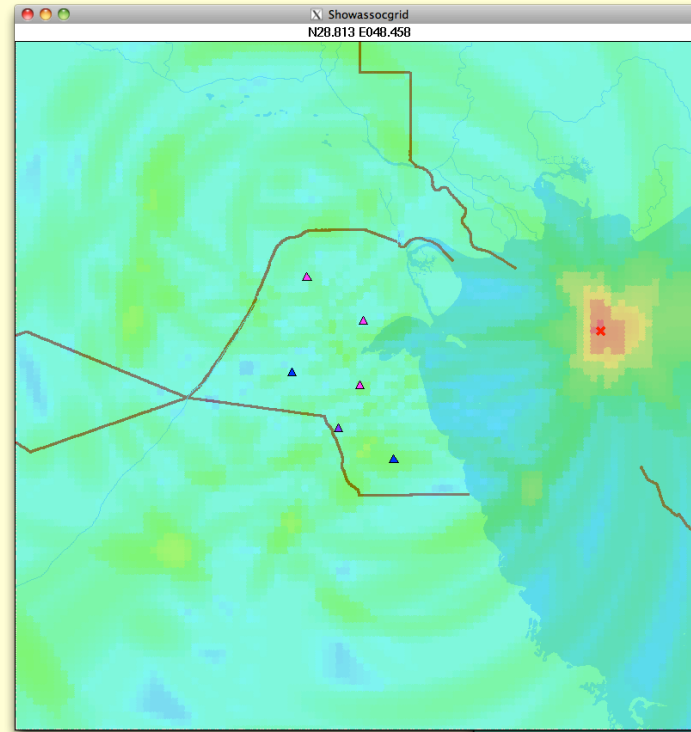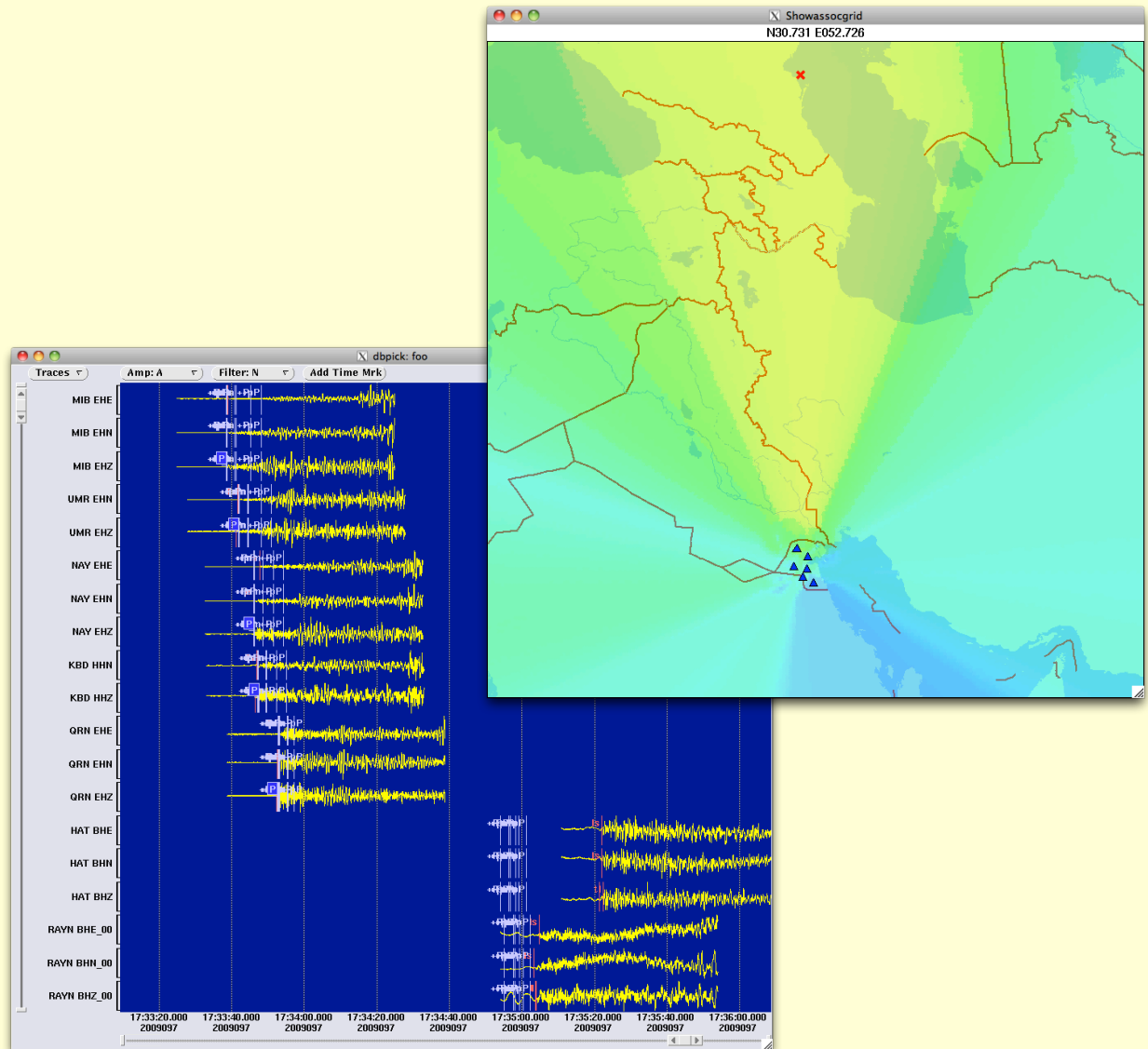


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Answer:

Not good results for events well outside network aperture. With regional events, generally, only P arrivals can be detected. Bad results regardless of numbers of stations. S detections cannot be used effectively if the P only solution is bad.

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Why Do Networks Produce Poor Solutions for Events Outside of the Network Aperture?
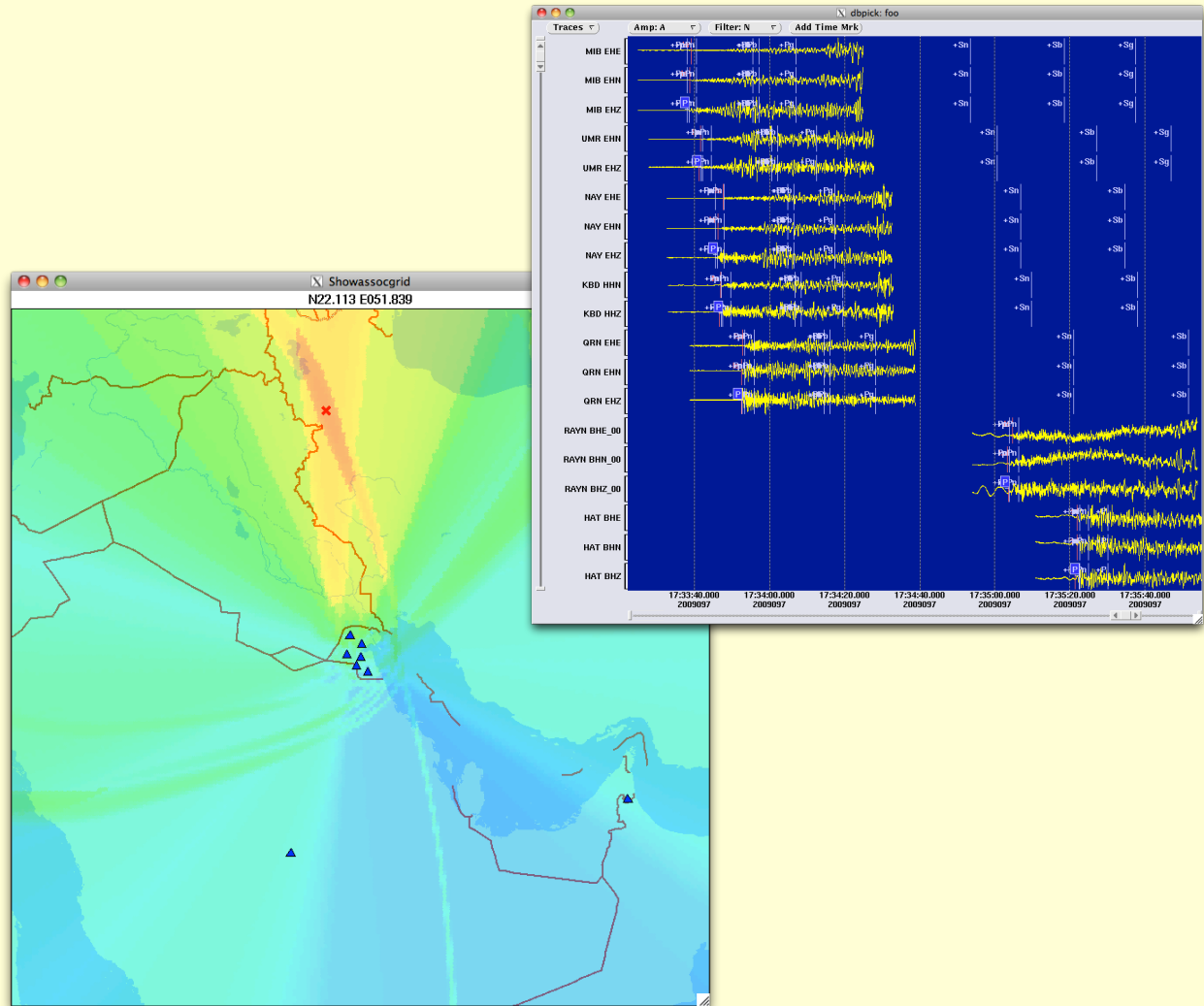
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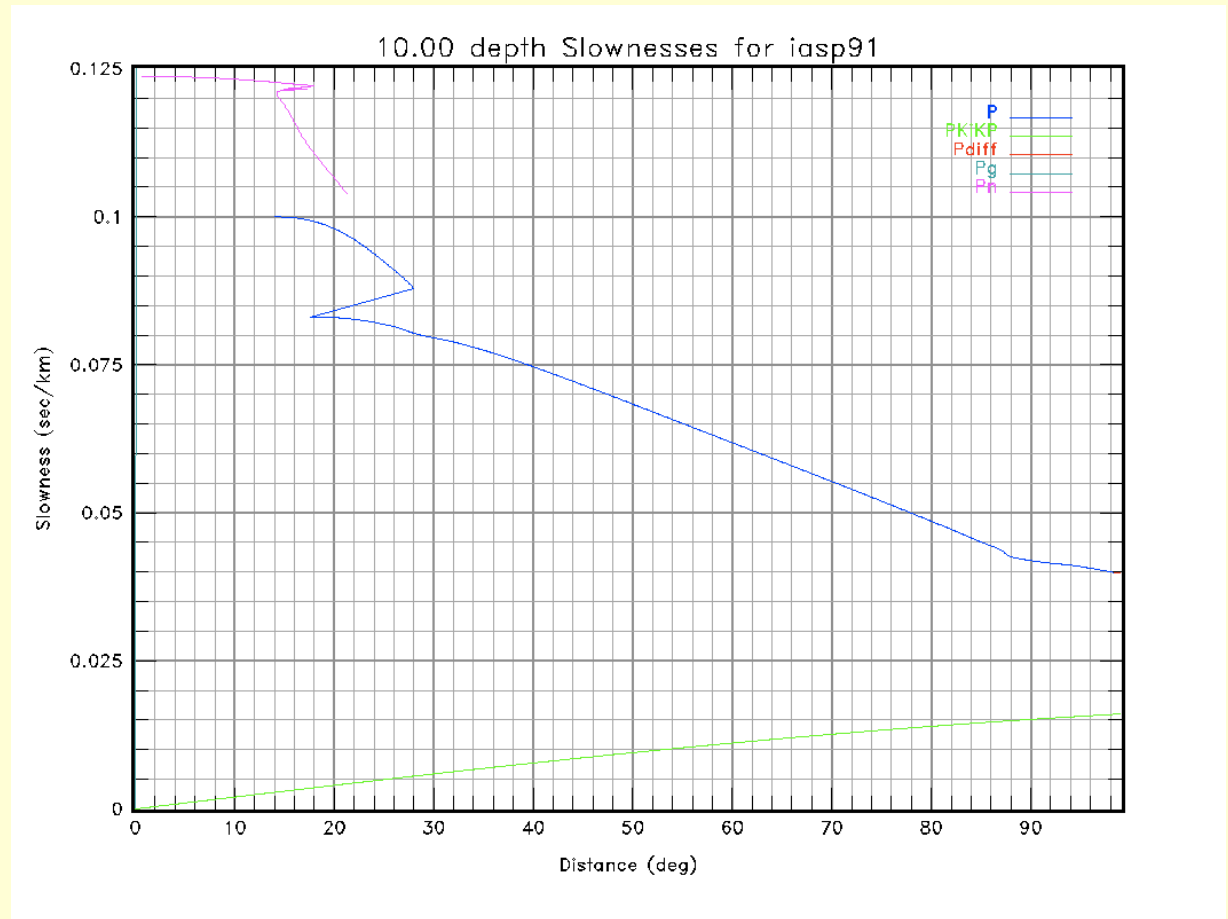
How Well Does the Associator Work for Small Networks? - Regional Events

Answer:

Results can get better if we add even a few stations geographically removed from the small aperture network.

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How Well Does the Associator Work for Small Networks? - Regional Events

Answer:

Adding a single station geographically removed from the small aperture network will only improve results significantly if the event is between the network and the added station.

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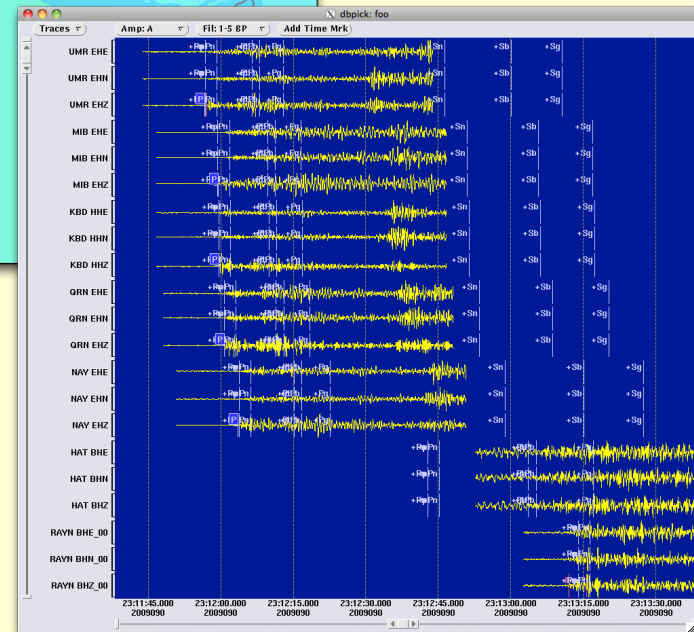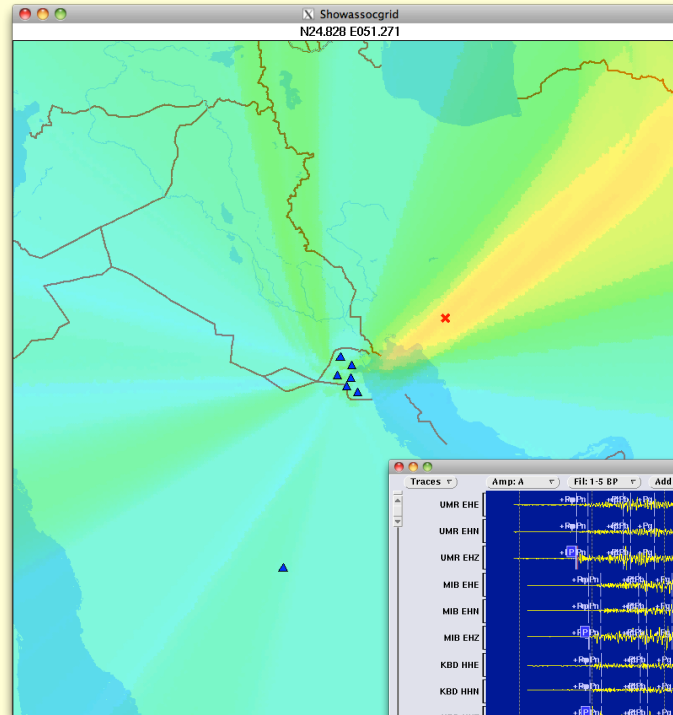
How Well Does the Associator Work for Small Networks? - Regional Events

Answer:

Including a few geographically removed stations can also cause problems. These situations must be resolved by an analyst looking at the waveforms.

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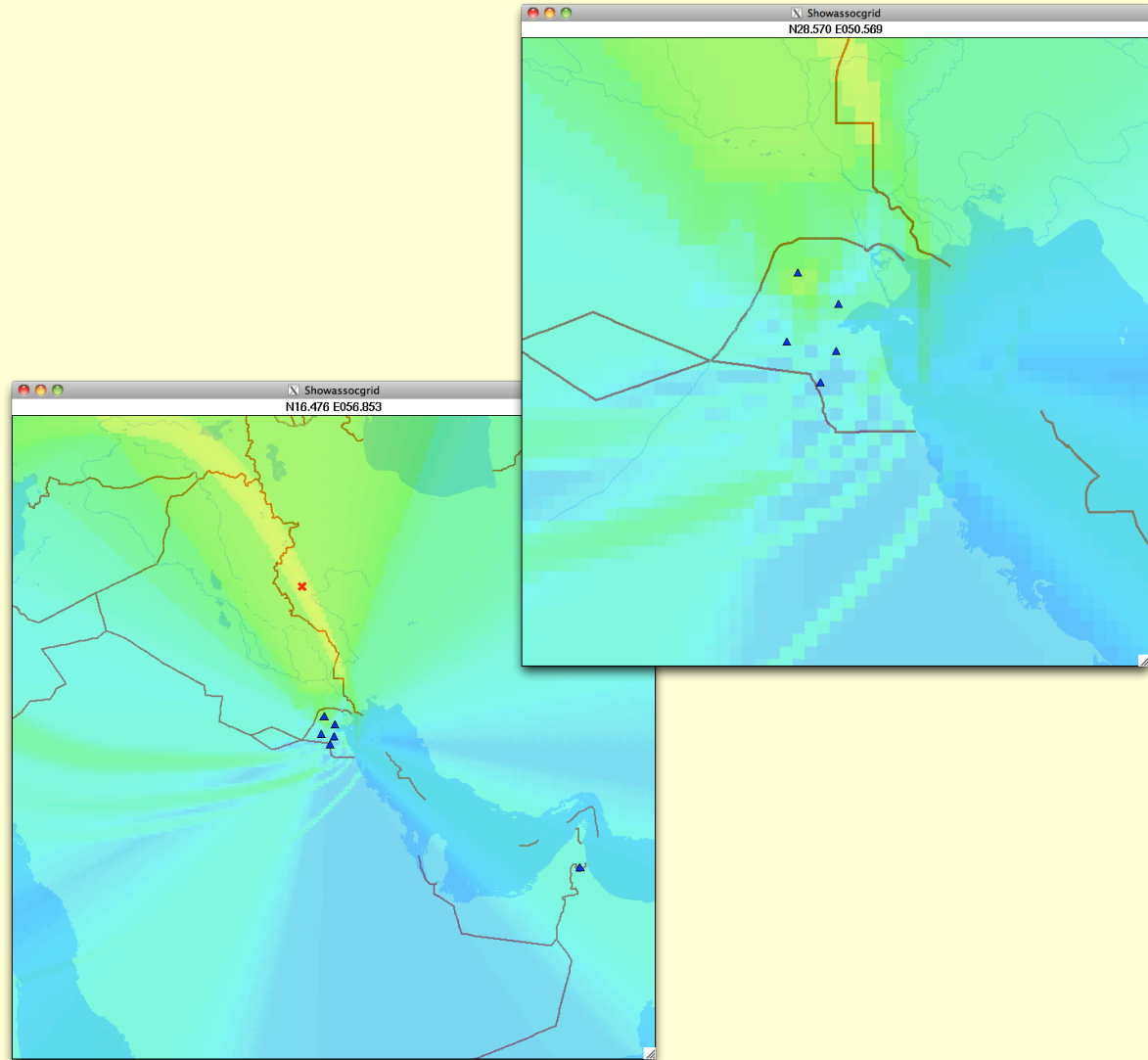
Data Quality

- A seismic station with poor data quality deteriorates the overall performance of the network. This is especially for networks with a small number of stations (< 30)

- Especially, timing problems can reduce the network performance to the point where it would be better to not have the station at all. A similar situation can exist with very noisy stations

- Given the expense and time involved in establishing a seismic station with real-time communications, it makes no sense to risk poor data quality by using poor equipment

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What Can We Do to Get the Most Out of Our Network?

1. Look for and fix stations with poor data quality (bad timing, bad communications, power problems, bad equipment, poor siting)

2. If you have a small aperture network, bring in other real-time data from neighboring networks and the GSN (the more, the better)

3. If you have small numbers of stations, bring in other real-time data from neighboring networks and the GSN (the more, the better)

4. Make sure your communications infrastructure can support substantial data import

5. Do not be bashful to send BRTT support requests (ALWAYS send rtsnapshot)

6. For the best support from BRTT, provide for BRTT to have internet access to all of your orbservers

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Antelope Configuration Recommendations - Spend Time With Your Data

1. What frequency ranges do you see in the data for events at various distance ranges.

2. Which stations have data quality problems.

3. Which stations have high noise levels.

4. Given your network geometry and quality, what is a reasonable expectation for the results your data can produce.

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Antelope Configuration Recommendations - Detections and orbassoc.pf sifting parameters

1. Use detection filters to discriminate between different categories of events; local/regional and teleseismic. Assign different `iphase` detection phase codes (in `orbdetect.pf`) for these different detection filters. Keep to just a few different filters.

2. Match the detection filters with the `orbassoc` grid types using the `phase_sifter` parameter in `orbassoc.pf`. Resist the temptation to use all detection filters for all grids.

3. Use only horizontal channels for S associations in `orbassoc.pf` by setting `S_channel_sifter` appropriately. Use only vertical channels for P associations in `orbassoc.pf` by setting `P_channel_sifter` appropriately.

4. Make sure all of your `orbassoc.pf` sifting parameters pass all of the channels you want to process (BHZ vs. BHZ_00, etc.)

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Antelope Configuration Recommendations - Orbassoc search parameters

1. Use the GSN processing template (from `rtdemo`) as a guide for setting up your system.

2. Bring in as much external data as you can. Bring in ALL of the GSN data, not just a dozen stations, especially if you have any desire to quickly produce earthquake locations for teleseismic great events.

3. Try to keep your `orbassoc.pf` configuration as simple as possible. Use the fewest number of grids as you can.

4. The most important parameters in orbassoc.pf to control the reliability of your locations are `nsta_thresh` (especially in table mode) and `phase_sifter`.

5. Stay away from the more exotic features, like distance weighting, unless you understand how it will affect the solutions. Understanding can come from experimental runs.

6. ALWAYS experiment first with parameter changes by running `dbgrassoc` using raw detections as input and assess the resulting solutions. This should be done with a copy of the database in an experimental area that does not affect your operational system.

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Streamlining Your Network Operations

- STOP USING `orb2db`! Use `cdorb2db` instead and run `db2msd` once a day to SEED compress old archive data.

- Pay attention to deprecated programs - they will disappear in the not so distant future. Deprecated programs are by definition no longer supported and replaced by better alternatives. In Antelope 5.0 the following deprecated programs will disappear; `dbml`, `orbmag`, `dbmag` and maybe some others.

- When reporting a problem to BRTT and requesting help, please, please, please, always, always, always include a `rtsnapshot` report. Don't wait for us to ask you. Don't assume it is some simple thing we can answer immediately.

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